Principles of Composting

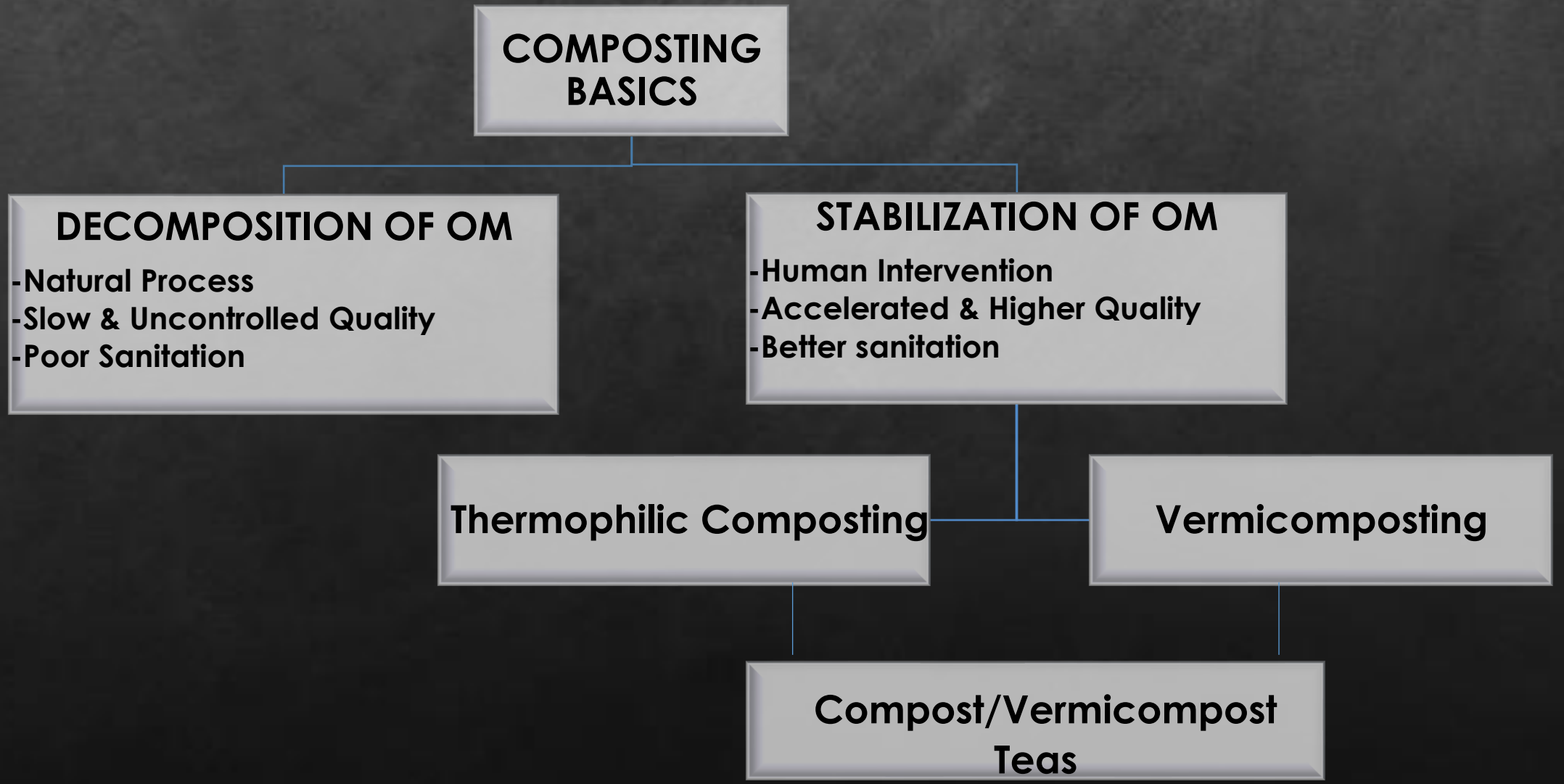
Bryan Smith

The Bigger Picture

"Compost is like money: It's not worth anything unless you spread it around"

- Author Unknown

Definition of Key Terms/Concepts



Introduction

What is Composting?

Composting is the **controlled biological** breakdown of organic materials in a predominantly **aerobic** environment under conditions that generate **high temperatures** by **thermophilic microbes**.

- Stabilised product (compost)
- Pathogen safe and free of weed seeds
- Humic like properties

Introduction

Why Compost?

- Alternative treatment technology for waste disposal.
- Helps prevent environmental pollution and degradation.
- Reduce waste materials dumped in landfills.
- A large amount of household and farm waste are organic or carbon based material.
- Saves money – low cost process where the end-product is beneficial.

Setting up a Compost

Material Transfer: Wheelbarrow, pick-up, front end loader, dump truck

Particle Size Reduction: grinder, sieve, chipper, lawn mower.

Mixing: shovel, hay fork, batch mixer, rotating mixing drum, bucket loader and water adding system (hose or water truck)

Carbon (C) to Nitrogen (N) Ratio

Carbon

- Brown feedstock
- Dry feedstock
- Availability depends on particle size and lignin content
- Serves as energy source for microbes

Nitrogen

- Green feedstock
- Wet feedstock
- Availability depends on particle size
- Nitrogen is linked to protein availability and is critical to microbial population growth

High C:N Ratio = slow decomposition & limited microbial activity.

Low C:N Ratio = loss of ammonia resulting in odor and loss of nutrient.

Porosity

Water

- Maintain moisture content between 40 – 60%
- Too much water increase settling, compaction and weight of pile.
- Too little water reduces microbial activity and decomposition.

Air

- Bulking material helps to ensure free airspace in the pile
- Air flow is needed for microbial respiration
- Air flow reduces odours resulting from lack of oxygen.
- The rate of aeration affects the temperature of the pile.

Temperature and Pile Heating

Compost temperatures increases rapidly during the initial stage

Active microbial respiration increases temperature

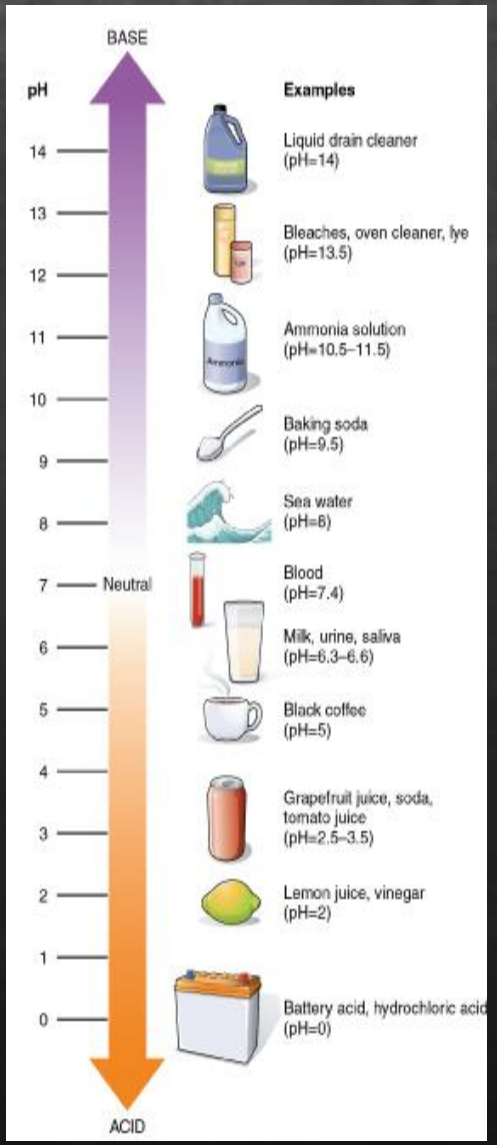
Self insulation of the pile sustains temperatures

As pile temperature decreases, so does the decomposition rate

AFFECTED BY

- Physical & biological composition
- Availability of nutrients
- Level of moisture
- Structure of the pile
- Rate of aeration
- Size of the pile
- Surrounding environment

pH



Source: USGS.gov

- Optimum pH for composting ranges between 5.5 – 8.5
  - Usually, pH initially rises then slightly falls in the cooling and maturation phase
  - Liming products can be used to raise the pH when using acidic feedstocks
  - At acidic pH, aerobic microbes die, and odors occur
- pH adjustment is important to avoid loss of ammonia during composting.

Soluble Salt Content (EC)

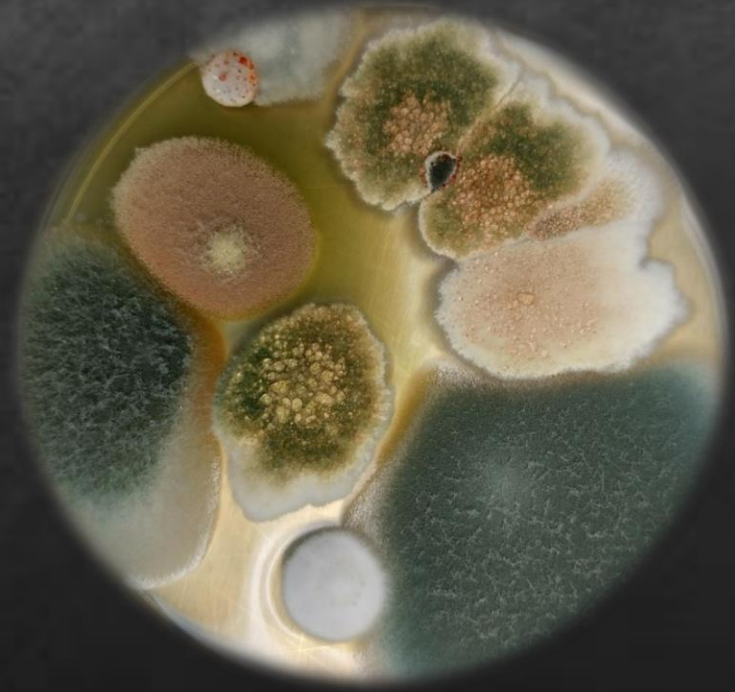
- Soluble salt content is reported in dS/m
- Soluble salts in finished compost range between 5 – 15 dS/m
- Less than 5 dS/m is preferred for crop production.
- Some of these salts are essential plant nutrients
- Excessive soluble salt content can affect seed germination and plant growth

Microbial Activity

Nutrients for metabolism

Temperature

Bacteria



Fungi

Oxygen for respiration

Moisture for mobility and enzymatic activity

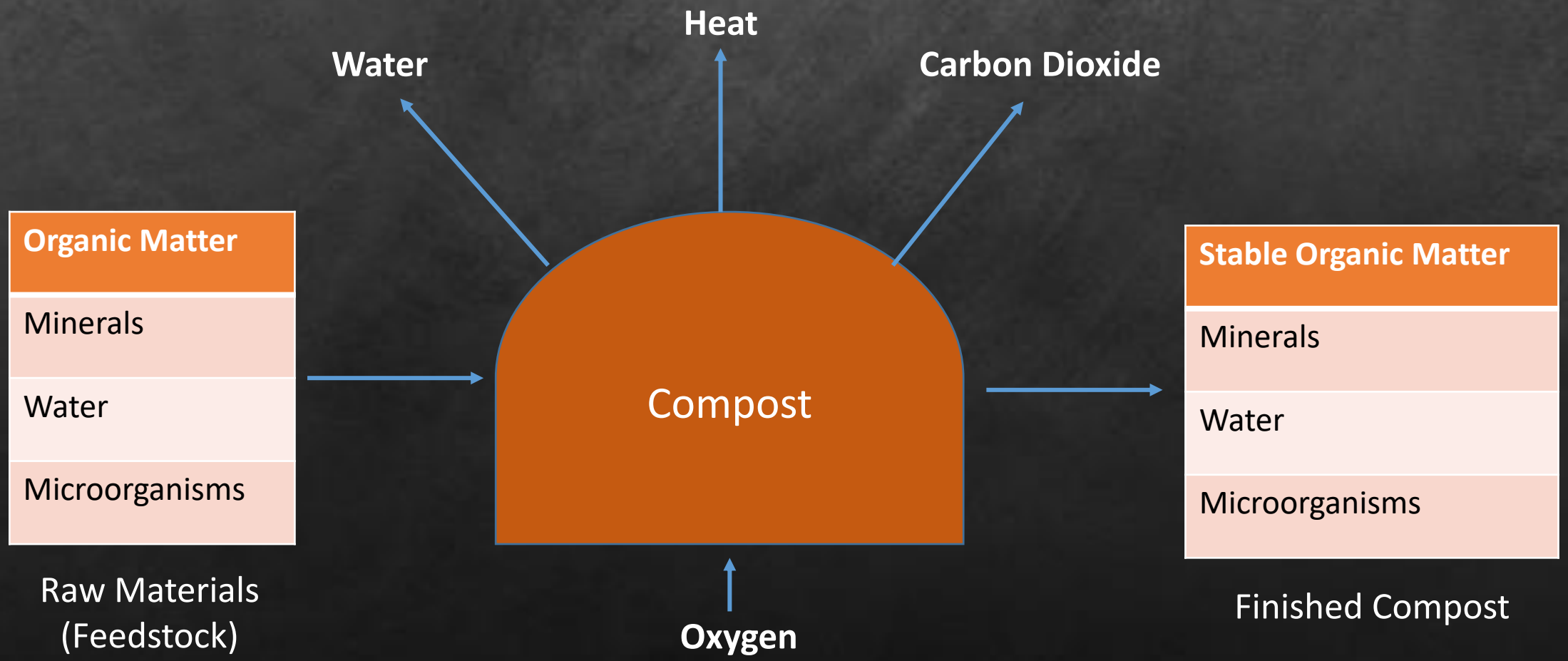
Time

Setting up a Compost Pile

Parameter	Target Range
Carbon to Nitrogen Ratio	20:1 – 40:1
Moisture Content	40 – 65 %
Particle size (inches)	0.5 - 2
pH	5.5 – 9.0
Temperature	43 - 67°C
Pile porosity	>40%
Bulk density	Compound mix in 5-gallon bucket < 25 lbs

Source: Field Guide to On-Farm Composting, 2019

The Composting Process



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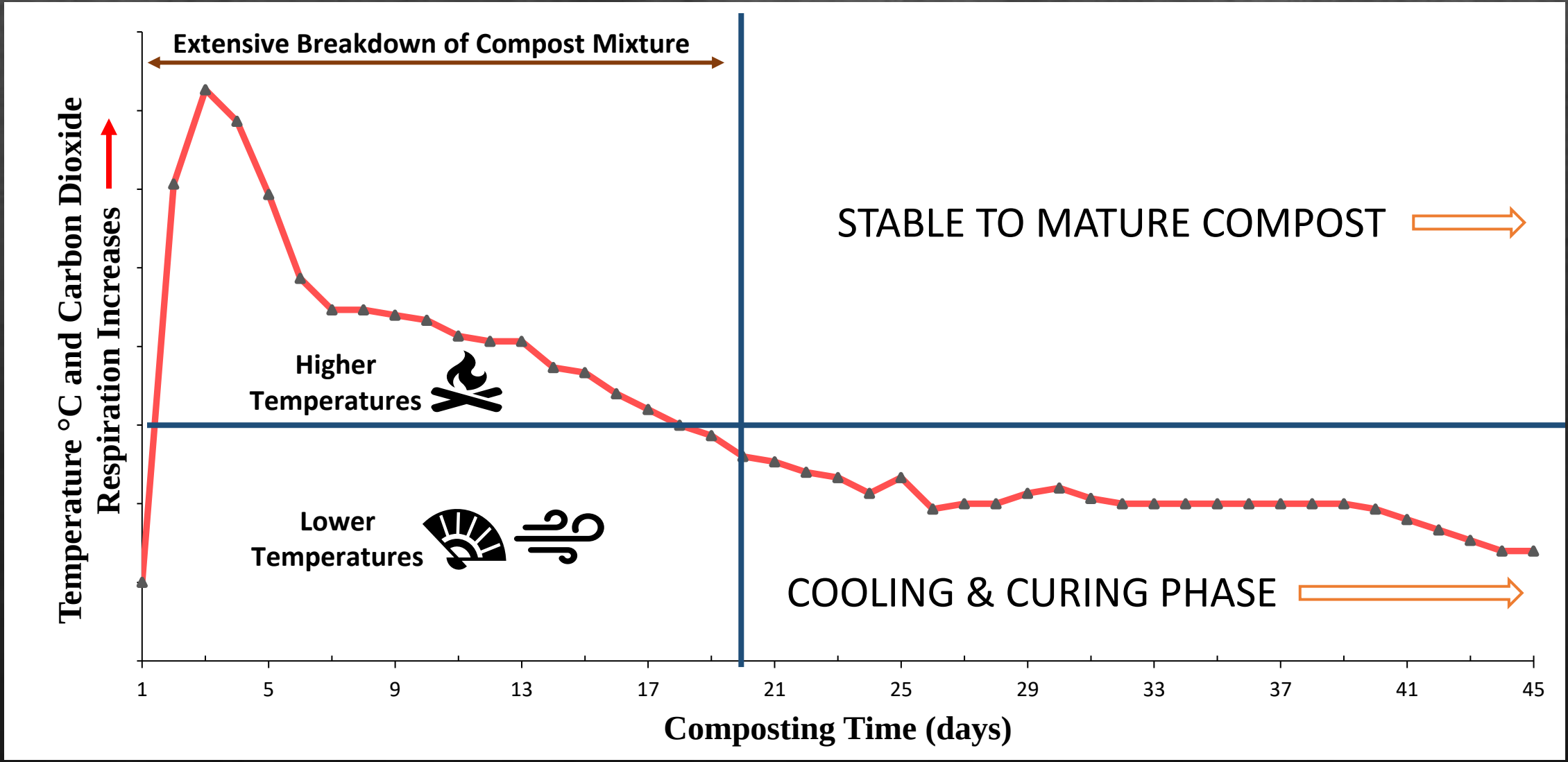
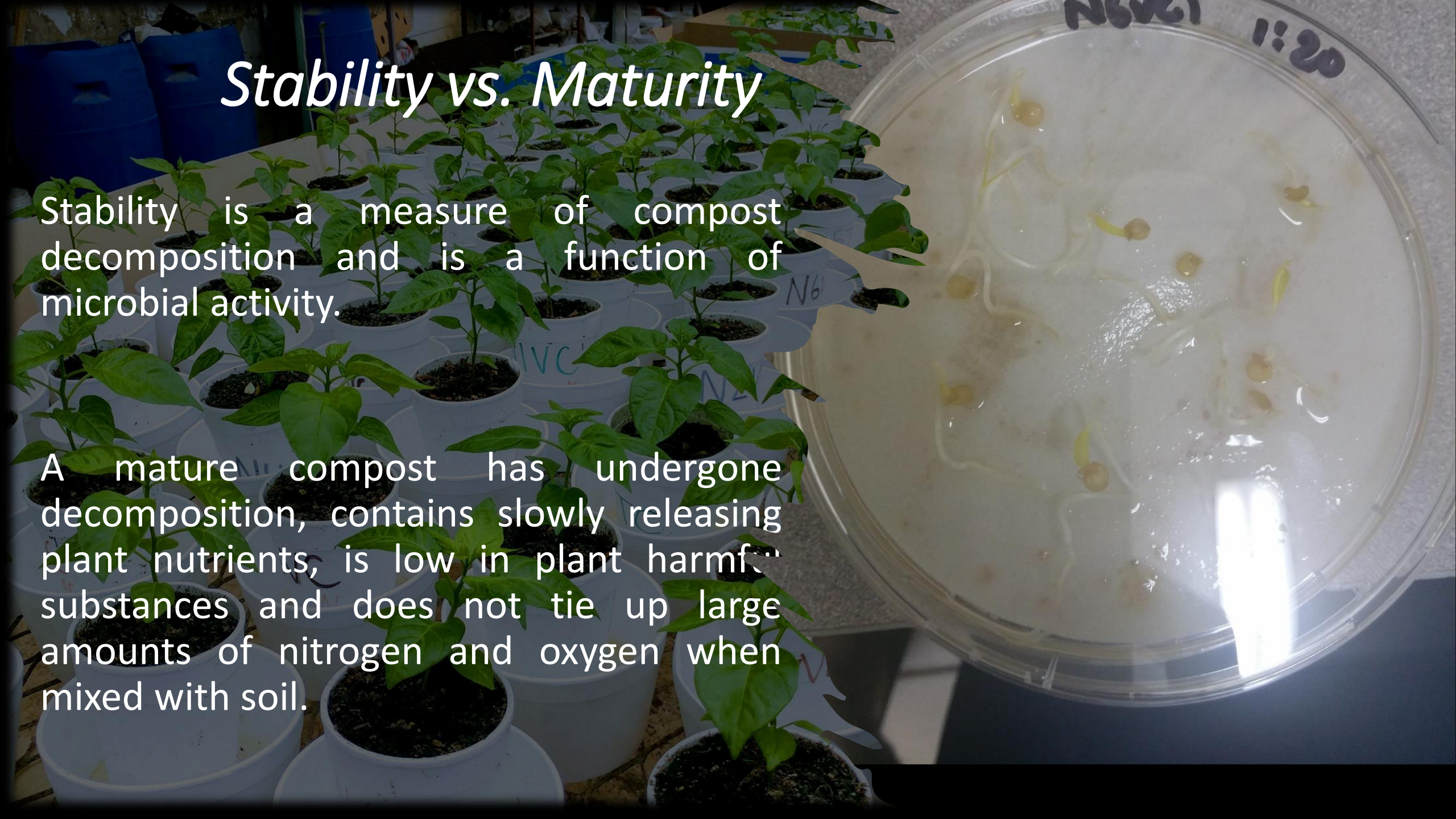
The Composting Process



Stability vs. Maturity

Stability is a measure of compost decomposition and is a function of microbial activity.

A mature compost has undergone decomposition, contains slowly releasing plant nutrients, is low in plant harmful substances and does not tie up large amounts of nitrogen and oxygen when mixed with soil.



Compost Properties

- ✓ Dirt-like material
- ✓ Uniform particle size and texture
- ✓ Homogeneous end-product

Physical

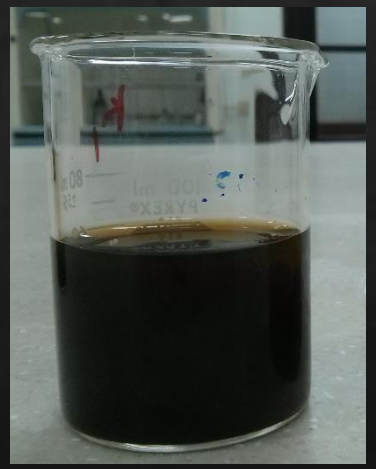
Compost Properties

- ✓ Free from inert material
- ✓ Free from viable weed seeds
- ✓ Good water holding capacity

Physical

Compost Properties

- ✓ Available nutrients
- ✓ Soluble salt content
- ✓ pH range and buffering capacity
- ✓ Rich in humic substances



Chemical

Compost Properties

- ✓ Rich in beneficial microorganisms
- ✓ Pathogen safe

Biological

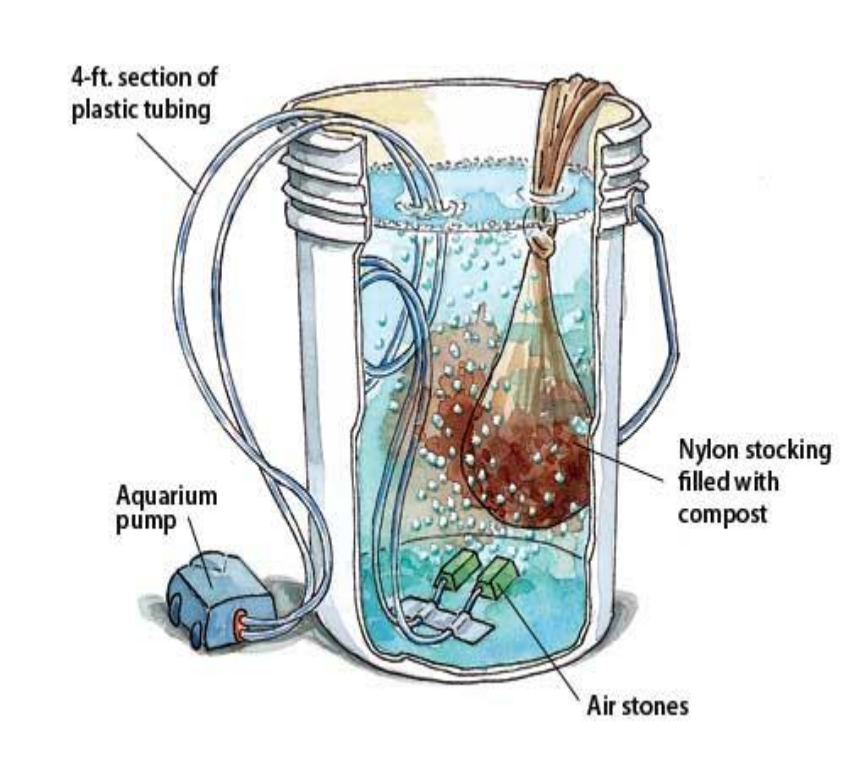
Compost Use

- ✓ Directly supplies micro- and macro-nutrients for plant growth.
- ✓ Improves soil structure and soil aggregate stability.
- ✓ Adds humus to the soil.
- ✓ Increase population of microbes in the soil that can help make nutrients available to plants.

Use

Compost Use

- ✓ Helps buffer soil pH.
- ✓ To make fermented aqueous extracts known as compost teas.



Use

Compost Use

- ✓ For disease suppression in crop production.
- ✓ Seedling starter and plant growth substrates.

Use

Compost Use

Table 1 showing Best Use of Composts Based on Maturity Index Rating

Rating	Potential Uses	Compost Characteristics
VERY MATURE	• Soil and peat-based container plant mixes. • Alternative topsoil blends, turf top-dressing.	• Well cured compost • No continued decomposition • No odours • No potential toxicity
MATURE	• General field use [pastures], vineyards and row crops. • Substitute and reduce use of synthetic fertilizer.	• Cured compost • Odour production not likely • Limited toxicity potential • Minimal Impacts on soil N
IMMATURE	• Land application to fallow soil. • Feedstock for compost.	• Uncured compost • Odours likely • High toxicity potential • Significant impact on soil N

Source: CCQC (2001, Supporting information , pg. 18)

Use

Factors Affecting Nutrient Availability and Disease Suppression in Compost

✓ Feedstock type

ANIMAL MANURES

FOOD WASTE

SEWAGE SLUDGE

✓ Composting method

Factors

Factors Affecting Nutrient Availability and Disease Suppression in Compost

- ✓ Organic matter decomposition level
- ✓ Compost Maturity
- ✓ Physical, chemical and biological attributes of compost
- ✓ Inoculation of compost with biological control agents

Factors

Mechanisms Involved in Suppression

In most instances, **suppressions are predominantly biological**, rather than chemical or physical in nature.

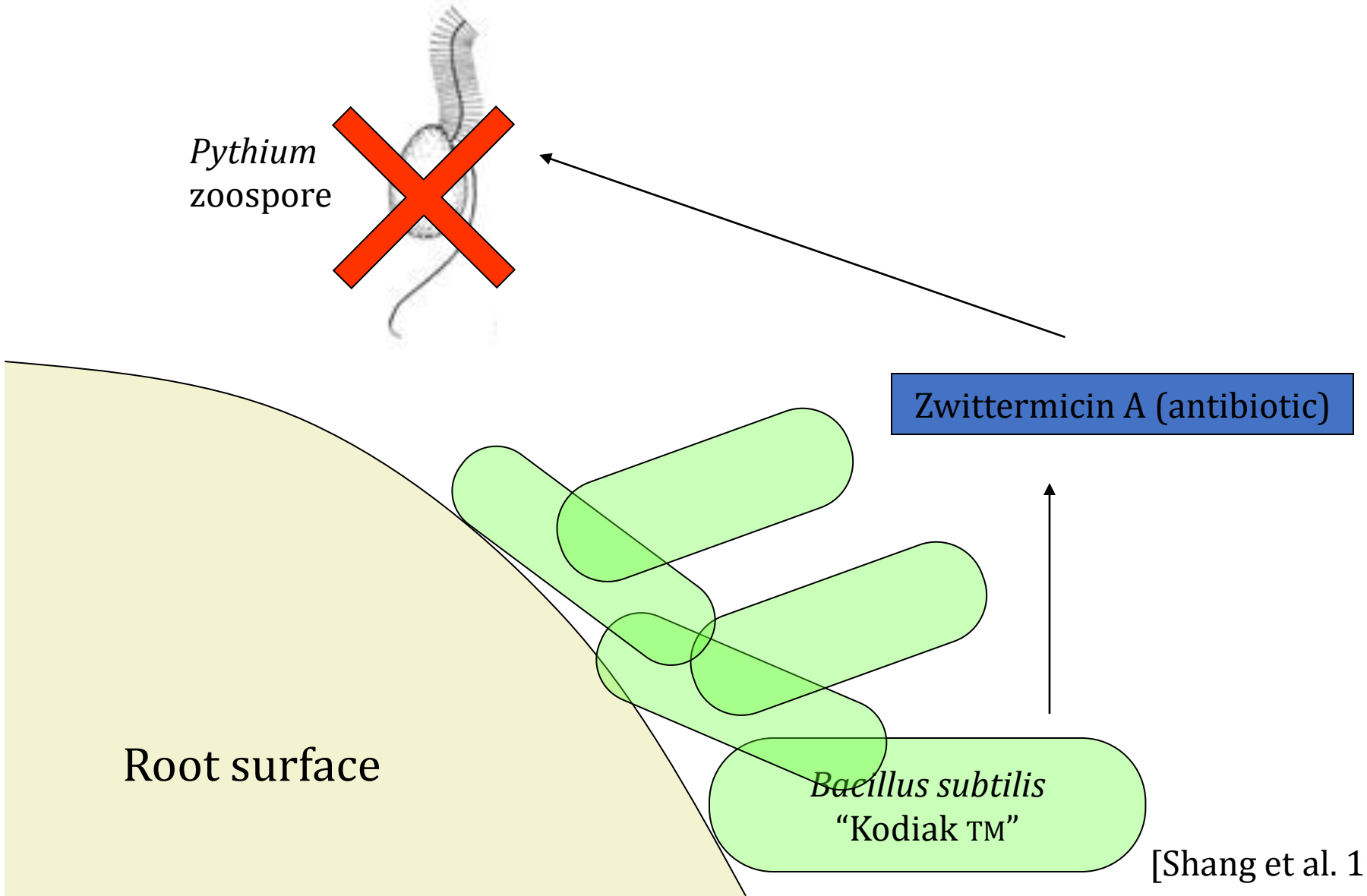
There are **four mechanisms** that have been described through which **compost and compost teas suppress plant pathogen (BCAs)**.

Mechanisms Involved in Suppression

- **Antibiosis**

Association between microorganisms where the production of specific metabolites or antibiotics by one organism affects the other.

Antibiosis



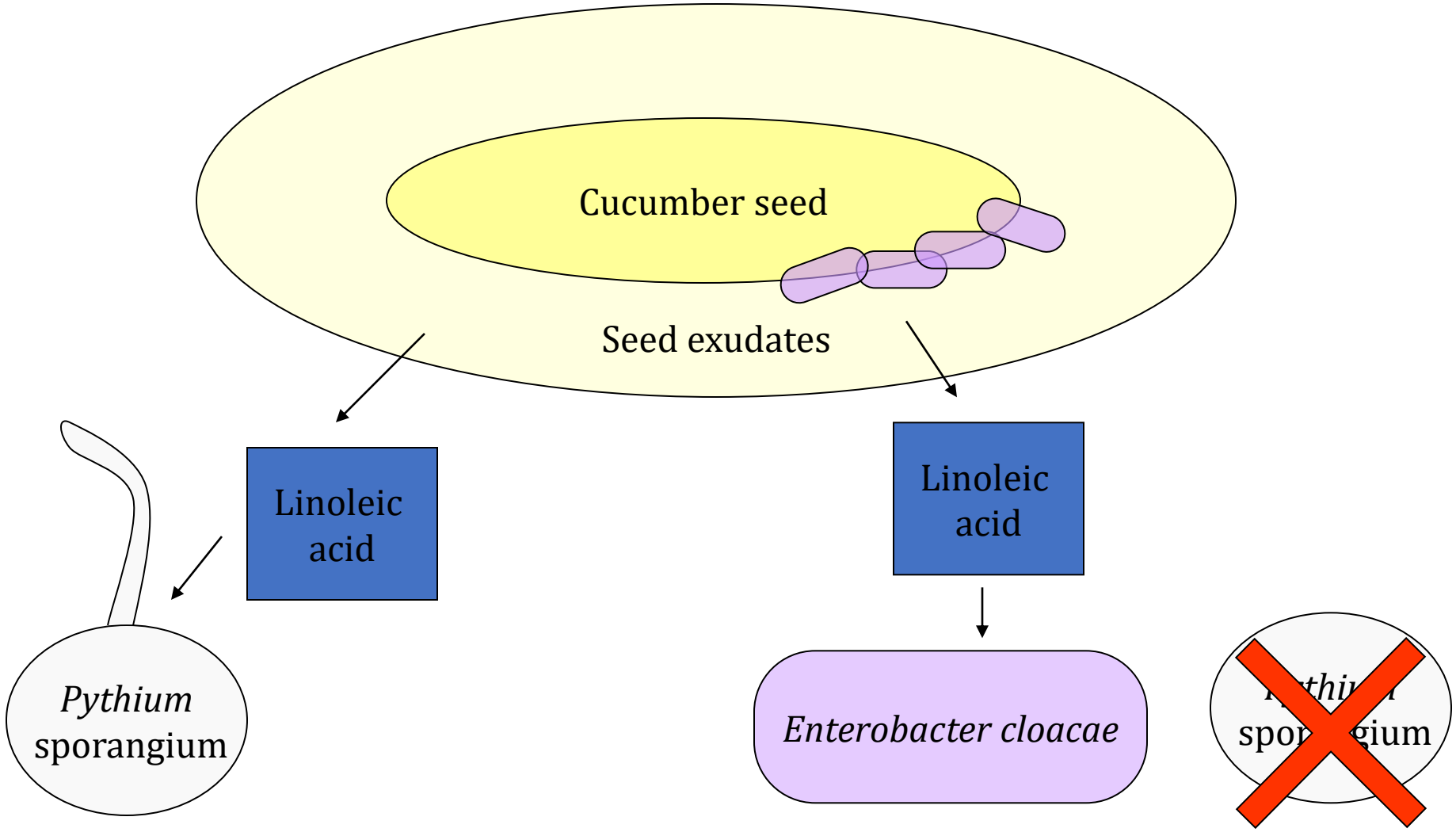
[Shang et al. 1999]

Mechanisms Involved in Suppression

- **Competition for nutrients**

Results when a non-pathogen successfully out-competes a plant pathogen for a resource, therefore leading to disease control.

Competition for nutrients



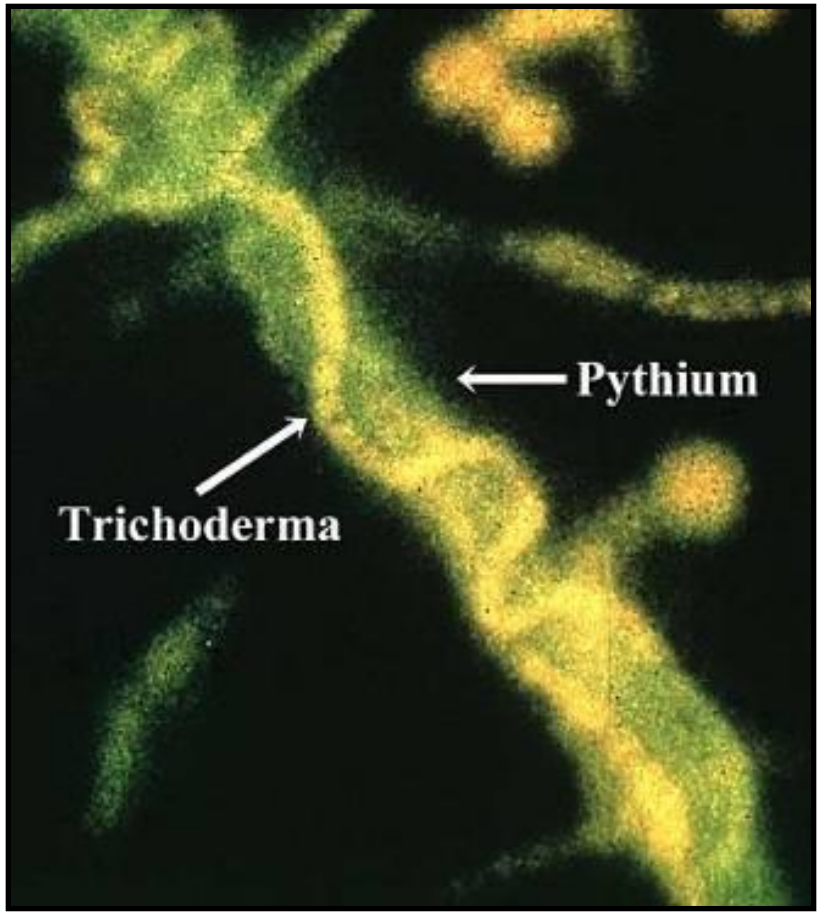
[van Dijk and Nelson 2000]

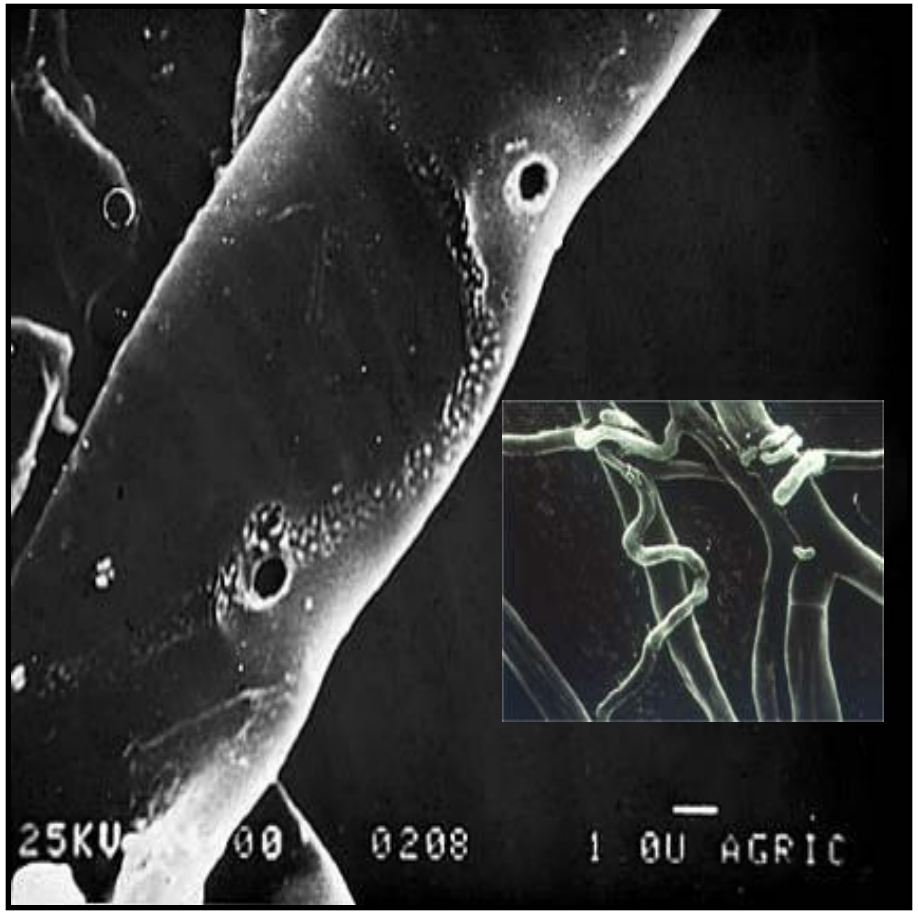
Mechanisms Involved in Suppression

- **Parasitism or Predation**

Consist of four stages which are chemotrophic growth, recognition, attachment and degradation of the host cell walls through the production of lytic enzymes.

Parasitism





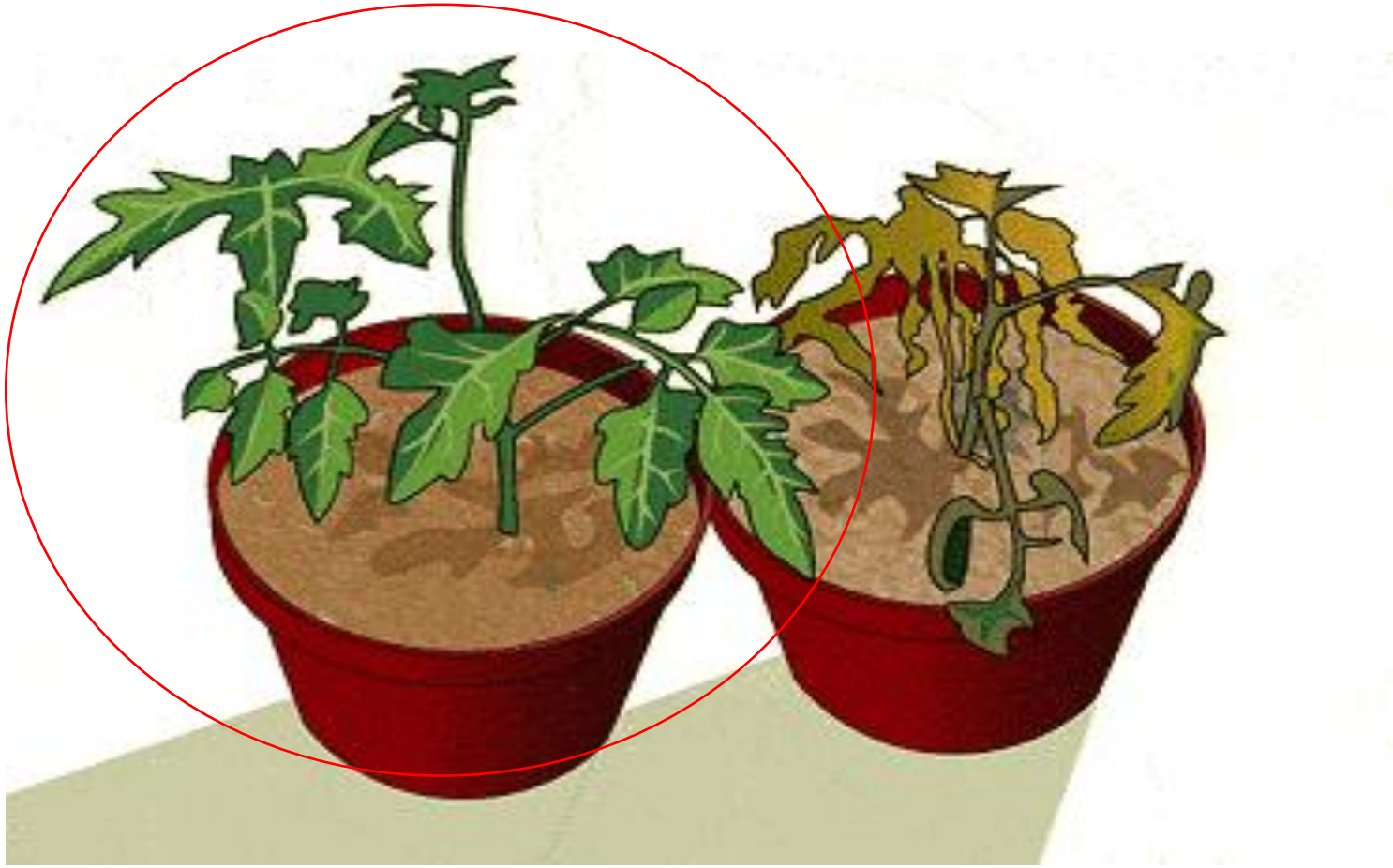
www.nysaes.cornell.edu/ent/biocontrol/pathogens/trichoderma

Mechanisms Involved in Suppression

- **Improved Plant Nutrition and Vigour**

Plant nutrition is enhanced by available and appropriate amount of nutrients in growing media, environmental conditions and PGPR (Plant Growth Promoting Rhizobacteria).

Improved Plant Nutrition and Vigour



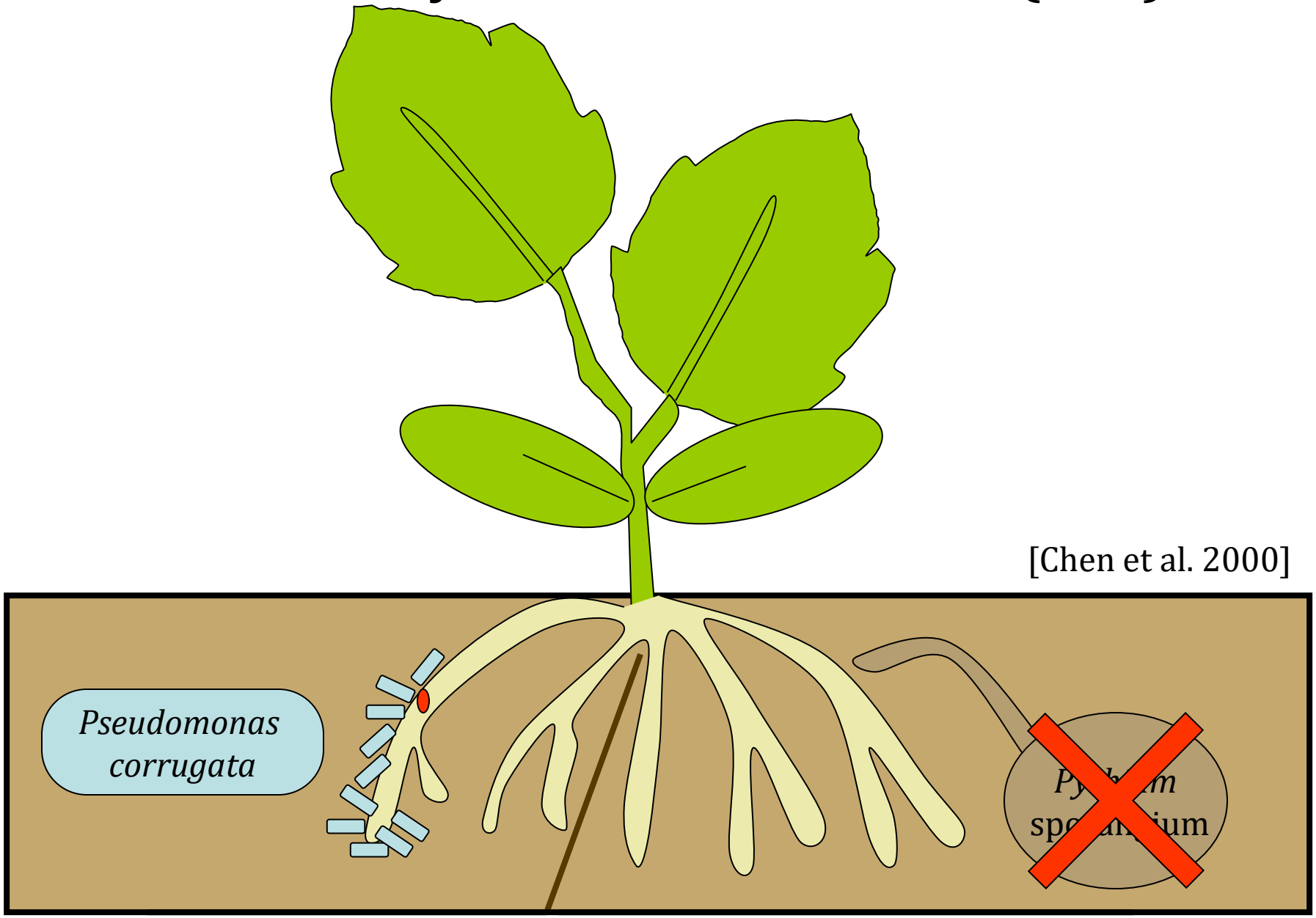
http://www.bbc.co.uk/schools/gcsebitesize/science/add_ocr_gateway/green_world/plantmineralsrev2.shtml

Mechanisms Involved in Suppression

- **Induced Systematic Resistance (ISR) or Induced Protection**

Triggered by beneficial microorganisms which enhance plant defence against a range of pathogens.

Induced Systemic Resistance (ISR)



[Chen et al. 2000]


ANY
QUESTIONS
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Further Information

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